4-1 SPREAD FOOTINGS

Using Working Stress Design (WSD), the design of spread footings was always a simple matter of keeping applied bearing pressures lower than site specific *allowable* bearing pressures. With Load Factor Design (LFD), the terminology changes to capture *ultimate* pressure values. This memo is intended to clarify the terms used in the Bridge Design Specifications (BDS), and to normalize communications with Geotechnical Services (GS).

Definitions (BDS 4.4.2)

Contact Surface = The bottom of the footing, located at a specific elevation.

Footing Width = The minimum plan dimension of the footing.

Gross Bearing Pressure = The total pressure demand or capacity at the contact surface. Gross pressure demands must include the weight of the footing and of all overburden soil from the contact surface to finished grade.

Net Bearing Pressure = The gross bearing pressure minus the pressure from the weight of soil between the contact surface and original ground. Limiting the net bearing pressure is critical where settlement controls the design.

q_{max} = Maximum Footing Contact Pressure. Used in WSD and LFD, this is the gross pressure applied to the contact surface. In LFD qmax includes load factors.

q_{all} = Allowable Bearing Capacity. Used in WSD only, this is the gross bearing pressure resisting q_{max}. Changes to the elevation or width of the contact surface will change q_{all}. As a rule, $q_{all} = q_n/3$ from BDS 4.4.7.1-2 and 4.4.7.1.2.

q_n = Nominal Bearing Resistance. Used in LFD, this is the gross capacity available to resist q_{max}/ϕ. The value of q_n depends on whether strength or settlement controls the design (BDS 4.4.7). If the settlement associated with service loads exceeds empirical structural threshholds – 50 mm for simple spans and 25 mm for continuous structures – then q_n will be less than q_{ult}. All settlement calculations will be performed by Geotechnical Services.

q_{ult} = Ultimate Bearing Capacity. This is the bearing pressure which will fail the soil using a strength criterion. It is calculated using the Terzaghi equation for general shear failure (BDS 4.4.7.1).

ϕ = The performance (or resistance) factor for soil bearing pressure in LFD (BDS 4.10.6). For Group VII seismic loads $\phi = 1.0$, otherwise $\phi = 0.5$.

For uniform application, the following guidelines should be observed:

- Caltrans uses WSD at all abutment and retaining wall footings. LFD is used at bent and pier footings because we can confidently estimate the maximum load on the foundation with column plastic hinge loads.
- In WSD all designs must satisfy: $q_{max} < q_{all}$
- In LFD all designs must satisfy: $q_{max} < \phi\, q_n$
- WinFOOT program (Version 2.1.1 and later): The user inputs the "Nominal Bearing Resistance (q_n)" from the Foundation Report. The footing and overburden weights are included in the factored loads.
- WinABUT program: The user inputs the "Maximum Bearing Capacity (Service)" which is the gross q_{all} from the Foundation Report.

Communication with Geotechnical Services

Sizing spread footings is an iterative process because the allowable bearing pressure depends on the size and depth of the footing. As a starting point, the geotechnical engineer will provide an estimate of q_{all} in the Preliminary Foundation Report. If no PFR is available, GS will provide guidance on the selection of q_{all} from BDS Table 4.11.4.1.4-1. The designer should use $q_n = 3q_{all}$ for preliminary load factor design calculations until GS reports a better value.

If the footing size changes during the design process then an update of q_{all} may be justified. Using BDS 4.4.7.1 note that q_{ult} – and to a lesser extent, q_{all} – increases linearly with the width of continuous footing. For square footings the relationship is more complex.

To prepare the Final Foundation Report (FFR), Geotechnical Services needs geometry and pressure data from Structure Design. This example table shows how this data should be listed in Design's Request for FFR memorandum:

Spread Footings

Location	Design Method	BOF Elevation (m)	Minimum Width (mm)	Required Bearing (kPa)		Controlling Load Group
				q_{all}	q_n	
Abut 1	WSD	3.00	3000	275	n/a	n/a
Bent 2	LFD	-2.50	8500	n/a	1050	I-VI
Bent 3	LFD	-2.50	8500	n/a	875	VII

If the designer communicates with Geotechnical Services throughout the process, the FFR will normally ratify the sizes and bearing pressures used by the designer. If dimensions have not been finalized, a smaller, more conservative estimate of the minimum footing width should be sent with the request.

Spread Footing Data Table

Spread Footing Data shall be included in the FFR and on the Contract Plans in the formats shown in Attachment 1.

Unlike portions of the Pile Data, none of the Spread Footing Data is necessary for contract compliance. However, its inclusion is a useful addition to the plans. With bearing values in hand, the engineer and project geologist can inspect the bearing strata and adjust the bottom of footing elevation. The pressures also provide a starting point for the future design of widenings and emergency supports.

Original signed by Richard D. Land

Richard D. Land

Deputy Division Chief

Engineering Services, Structure Design

JPL/pkml

FORMAT FOR THE FINAL FOUNDATION REPORT :

Spread Footing Data Table

Support Location	Minimum Footing Width	Bottom of Footing Elevation	Recommended Bearing Limits	
			WSD[1]	LFD[2]
			Allowable Bearing Capacity q_{all}	Nominal Bearing Resistance (q_n)
Abut 1			XX kPa	N/A
Bent 2			N/A	XX kPa
Pier 3			N/A	XX kPa
Abut 4			XX kPa	N/A

Notes: 1) Working Stress Design, (WSD), the Maximum Contact Pressure, (q_{max}), is not to exceed the recommended Gross Allowable Bearing Capacity, (q_{all}).

2) Load Factor Design, (LFD), The Maximum Contact Pressure (q_{max}) divided by the Strength Reduction Factor (ϕ) is not to exceed the Nominal Bearing Resistance (q_n).

Format for the Contract Plans:

Spread Footing Data Table

Support Location	Allowable Bearing Capacity, q_{all}	Nominal Bearing Resistance, q_n
Abut 1	XX kPa	N/A
Bent 2	N/A	XX kPa
Pier 3	N/A	XX kPa
Abut 4	XX kPa	N/A